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Bryans
Southern
Instruments
Limited

LOGARITHMIC AMPLIFIER TYPE 26236

OPERATION & SERVICING MANUAL

TO BE USED IN CONJUNCTION WITH MAINFRAME MANUAL, 26000 SERIES

MP MASTER
MA23522

MODEL 26236

LOGARITHMIC AMPLIFIER

OPERATION AND SERVICING MANUAL

TO BE USED IN CONJUNCTION WITH MAIN 26000 OPERATION AND SERVICING MANUAL.

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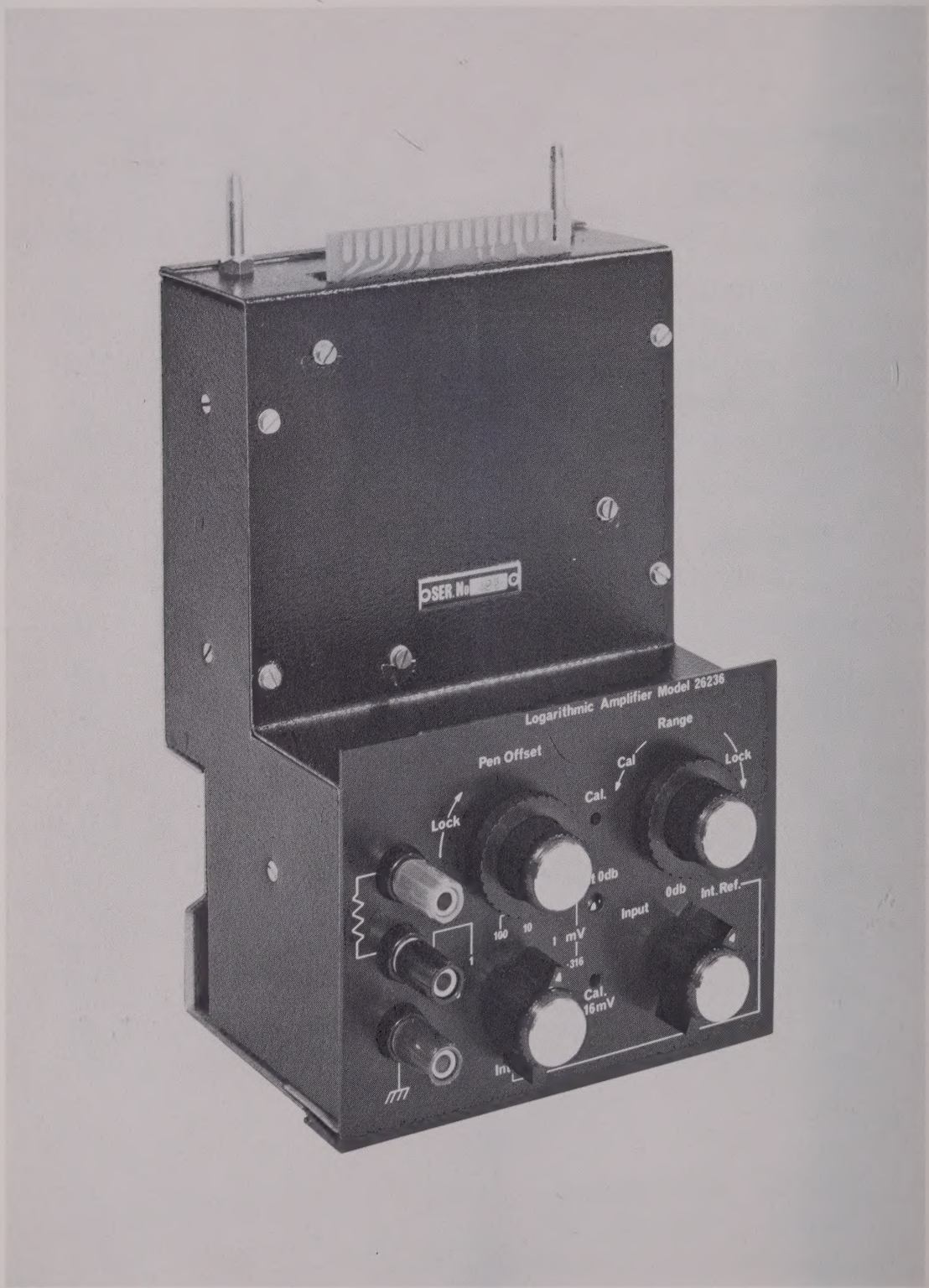


Fig,1 Model 26236 Logarithmic Amplifier Module

1. INTRODUCTION

The Model 26236 Logarithmic Amplifier is a plug-in module which effects the accurate logarithmic compression of d.c. inputs over a wide dynamic range. It is for use with any of the 26000 series X-Y recorders and may be installed in either axis for either linear-log plots when used in conjunction with a linear pre-amplifier, or log-log plots when two Logarithmic Amplifiers are installed.

Its use makes possible the plotting of curves on logarithmic scale graph paper or alternatively on linear paper for direct reading in decibels.

Extensive use of integrated circuits has permitted a high packing density enabling both the logarithmic conversion and servo pre-amplifier functions to be performed in a single module. In addition a comprehensive range of facilities are provided which include a floating input together with variable scaling and six internal reference source levels.

2. SPECIFICATION

Input	Floating
Input Voltage Range	316uV - 100V d.c. (110dB or 5½ decades)
Maximum Input Voltage	± 110V (Input protected against full reverse input voltage)
Input Impedance	100K ohm
Maximum Source Impedance	1K ohm/mV
Accuracy	0.25dB (3% referred to input) at 10mV - 100V 0.33dB (4% " " ") " 1mV 1.0 dB (12% " " ") " 316uV
Internal Reference Accuracy	0.17dB (2% referred to input), all levels
Scale Factor	4dB/cm (10dB/in.), calibrated 1.6dB/cm (4dB/in.), max. scale expansion
Maximum Dynamic Range	110dB (5½ decades), A3 X axis 110dB (5½ decades), A3 Y axis 100dB (5 decades), A4 X axis 70dB (3½ decades), A4 Y axis
Input Offset Current	-2pA, typical
Common Mode Voltage	500V max.
Common Mode Rejection	0.2dB pp, typical, for 25V r.m.s. common mode voltage from 10K ohm source at 50 Hz line frequency
Noise	10uV pp, typical
Warm-up Time	15 minutes
Drift	35uV over 8 hours, typical
Ambient Temperature Range	10 - 35°C.
Typical Slewing Speed	As recorder main frame, 10mV-100V, X and Y axes 50 cm/sec (20in/sec), 1mV, Y axis 30 cm/sec (12in/sec), 1mV, X axis 20 cm/sec (8in/sec), 316uV, Y axis 10 cm/sec (4in/sec), 316uV, X axis

Power Requirements	1.6W, derived from recorder main frame
Dimensions	216 x 127 x 118mm ($8\frac{1}{2}$ x 5 x $4\frac{5}{8}$in)
Weight	1.1. Kilogrammes

FACILITIES

Pen Offset Control	Allows OdB to be set at any position on chart, lockable.
Set OdB Control	Allows any level in input range to be adjusted to be the OdB reference level for ease of calibration and scale factor setting.
Variable Range Control	Scale expansion factor 2.5 : 1 min, lockable
6 Internal Reference Levels	0.316mV, 1mV, 10mV, 100mV, 1V, 10V.
Calibration Control	Accessible through a small hole in the front panel, this control provides fine gain adjustment to suit the recorder to which it is fitted.

3. OPERATION

3.1 Principles of the Logarithmic Scale.

In using the Logarithmic Amplifier it is important to have a basic understanding of the logarithmic scale. Power levels are expressed in decibels given by the equation:-

$$dB = 10 \log_{10} (P_2/P_1)$$

where dB is the power level in decibels of the power level P_2 with respect to the arbitrarily chosen power level P_1. Thus at P_1 :-

$$dB = 10 \log_{10} (P_1/P_1)$$

$$= 10 \log_{10} (10)$$

$$= 0dB$$

so that P_1 is the zero dB reference level. This is normally taken to be 6 milliwatts.

In a similar manner it is also possible to express power levels by means of voltage ratios provided that these are referred to a constant load impedance. The equation then becomes:-

$$dB = 20 \log_{10} (V_2/V_1)$$

The factor of 2 being due to the square law relationship between voltage and power. Each decade of voltage, therefore, represents a power level difference of 20dB. For example, if 10mV is taken as the zero dB level, 1V will be represented by 40dB corresponding to a ratio of 100:1 i.e. 2 decades. On the same scale 1mV will be at a level of -20dB corresponding to a ratio of 1:10 i.e. -1 decade. The power level of 10dB which is half a decade of voltage results from a voltage ratio of 3.16:1, the figure of 3.16 being the square root of 10.

With the Model 26236 Logarithmic Amplifier d.c. voltages can be plotted over a dynamic range of 316,000:1 (110dB) between 316uV and 100V. Voltages outside these limits are not specified. Also, as the logarithm of zero is minus infinity, an input of zero or a very small voltage will cause the amplifier to drive the pen carriage of the recorder towards the negative end stops.

The calibration of a logarithmic scale is more difficult than a linear scale as the zero reference level does not correspond to a zero voltage input, and to overcome this difficulty a set of internal reference sources has been incorporated covering $4\frac{1}{2}$ decades. When calibrated the scale factor is 4dB/cm. (10dB/in.) and this can be expanded to suit various log scale graph papers.

Thus the output on the recorder is directly proportional to the logarithm of the input voltage, the pen moving equal distances for equal ratios of input voltage, as opposed to equal differences of voltage magnitude in the case of a linear amplifier. The advantage of this system of graphic display is that large and small signals can be plotted on a single sheet of graph paper with virtually a constant accuracy independent of scale deflection.

3.2 Installation.

The Logarithmic Amplifier Module can be quickly and simply installed into a 26000 series recorder by carrying out the following instructions.

First remove the front trim cover by pulling it firmly out of its two securing sockets on either side of the recorder.

Then take away the front cover plate by removing the fixing screws beneath the recorder. There are three such screws on the A4 size model and four on the A3.

Having decided in which axis the Log Amplifier is to be used i.e. X, Y1 or Y2, the next step is the removal of the module, if any, already installed in that axis position. Take out the two screws holding the module to the support bar on the underside of the recorder and then unplug the module.

Plug in the Log Amplifier Module ensuring that its two locating spigots and its printed circuit plug are properly engaged with the two guide holes and the socket on the main frame.

Finally, replace the module fixing screws, the front cover and front trim cover.

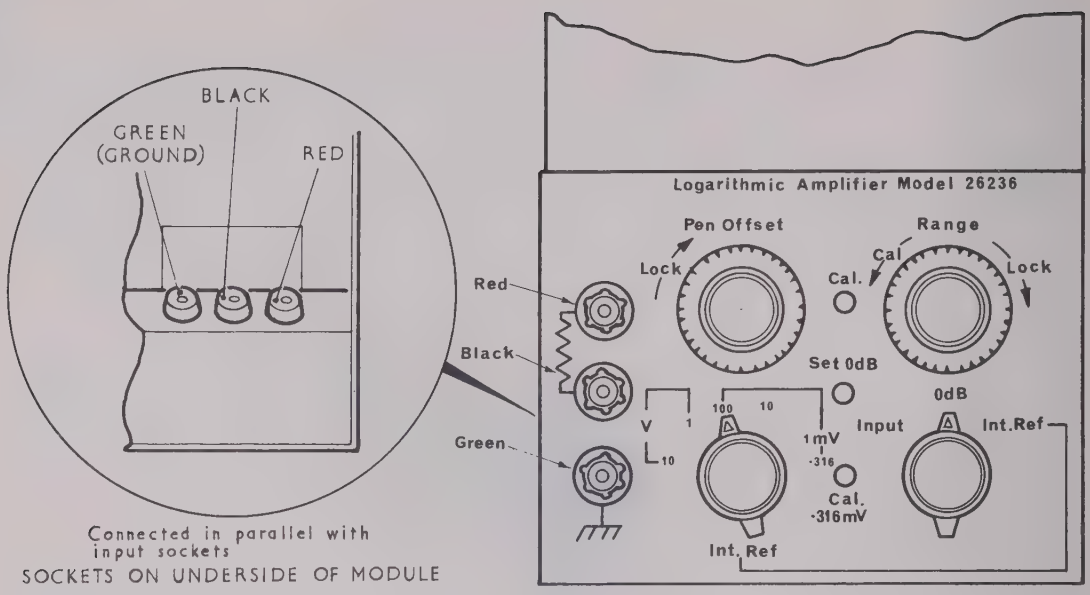
The Logarithmic Amplifier is now ready for use.

3.3 Operating Controls.

The positions of the panel controls and underside sockets are shown in figure 2.

The controls are as follows:-

(1) Input terminals/sockets - RED - BLACK - GREEN. The input to the Log Amplifier is between the RED and BLACK terminals. On application of an input signal the RED terminal should always be at a positive potential with respect to the BLACK terminal for correct operation. The GREEN terminal is connected to earth and may be used to earth the input or to earth any shielding on the input leads. All three terminals are wired in parallel with the underside input sockets (see (9)).



Fig,2 Panel Controls

(2) Selector switch - INPUT - 0dB - INT. REF.

A 3-position rotary switch:-

(i) When switched to INPUT the input terminals are connected to the Log Amplifier and the recorder will plot the log of the input signal.

(ii) When switched to 0dB the recorder pen will take up a position corresponding to its own internal 0dB reference level. On this switch position the RED input terminal is disconnected from the Log Amplifier.

(iii) When switched to INT. REF. (INTERNAL REFERENCE) the recorder pen will take up a position corresponding to the level set on the Internal Reference switch. The RED input terminal is again disconnected from the Log Amplifier.

(3) INTernal REFerence switch.

A 6-position rotary switch which selects any of the 6 internal reference voltage sources i.e. 10V, 1V, 100mV, 10mV, 1mV and 0.316mV. These are useful for calibration purposes when the selector switch is set to INT. REF.

(4) RANGE control.

A 10-turn lockable potentiometer which enables the scale factor to be continuously expanded by up to X2.5 from the calibrated value of 4dB/cm (10dB/in.), when the RANGE control is fully anti-clockwise, to 1.6dB/cm (4dB/in.). Thus a wide range of log scale graph papers may be used.

(5) PEN OFFSET control.

A 10-turn lockable potentiometer which is used to set the pen to any desired position along the axis either for the 0dB condition or any particular level of input signal. All subsequent plots are then made with reference to this offset pen position.

(6) CALibration control.

Accessible through a small hole in the control panel by means of a small screwdriver, this single-turn potentiometer enables the scale to be calibrated when the RANGE control is in its calibrated position. It is used in conjunction with the internal reference levels and has the function of compensating for components between one Log Amplifier and another, between different recorder main frames and between axes of a single main frame.

(7) SET 0dB control.

A 10-turn potentiometer accessible through a hole in the control panel by means of a screwdriver. It enables the internally generated voltage, which is proportional to the logarithm of the input voltage, to be adjusted so that it equals the internal 0dB reference level of the Log Amplifier, i.e. 0V with respect to the BLACK input terminal. This can be set for any desired level of input voltage and serves the purpose of facilitating calibration and scale factor adjustments by providing a zero reference level which gives a pen position that is virtually independent of changes in the CAL and RANGE control settings.

(8) CALibrate 0.316mV control.

A single turn potentiometer accessible through a small hole in the control panel by means of a small screwdriver which is used to calibrate the 0.316mV level. This is necessary to compensate for any long term drift which may occur at the low end of the dynamic range. It is normally used in conjunction with the 0.316mV internal reference source.

(9) Underside input sockets - RED - BLACK - GREEN.

These are wired in parallel with the input terminals on the front panel (see (1)) and provide for rear entry of the input signal line.

3.4 Calibration.

Calibration of the Log Amplifier is necessary after installation and should be repeated subsequently each time before use or when it is re-installed in a different axis or recorder main frame. The calibration instructions are as follows:-

With the function switch in the 0dB position on the recorder allow 15 MINUTES WARM-UP PERIOD.

Place a sheet of linear metric (or English) paper on the recorder.

By means of the PEN OFFSET control move the pen to half scale.

Turn the RANGE control to its calibrated position i.e. fully anti-clockwise and switch to INTERNAL REFERENCE.

Switch the INTERNAL REFERENCE switch to 100mV and adjust the sub-panel SET 0dB potentiometer with a small screwdriver so that the pen returns to the 0dB line.

Switch to 10V and adjust the CAL potentiometer to give 10 cm. (4 in.) deflection corresponding to 2 decades i.e. 40 dB.

Switch to 0.316mV and adjust the CAL 0.316mV potentiometer to give a deflection of -12.5 cm. (-5 in.) corresponding to -2½ decades i.e. -50 dB.

When calibration is performed in the Y axis of an A4 recorder, repeated use of the PEN OFFSET control is necessary to ensure that the pen does not exceed full scale deflection in either direction.

Check the full range of internal reference sources from 0.316mV to 10V. The Log Amplifier will now be calibrated with a scale factor of 4dB/cm. (10dB/in.) over the full dynamic range from 0.316mV to 100V.

For input voltages between 10V and 100V no further calibration is necessary, but if required the calibration at 100V may be checked by the application of a 100V external reference source.

3.5 Operating Instructions.

After the required 15 MINUTES WARM-UP PERIOD and calibration to the preceding calibration instructions the LOG AMPLIFIER is ready for use.

Having decided upon the dynamic range to be covered, select a suitable paper either log or linear. Log paper is useful for the indication of the actual magnitude of the compressed input signal, linear paper for a direct reading in decibels (4dB/cm to 1.6 dB/cm or 10dB/in. to 4dB/in.).

Switch to 0dB. The input is now disconnected from the log amplifier and the pen will have taken up a position corresponding to 0dB.

Move the pen by means of the pen offset control to the maximum desired pen deflection e.g. full scale deflection. This will be the 0dB position.

Switch to INTERNAL REFERENCE and switch the INTERNAL REFERENCE switch to the level desired for 0dB (in this case the highest voltage to be measured).

By means of a screwdriver, rotate the set zero control mounted beneath the panel until the pen returns to the 0dB line.

Switch to the highest voltage to be measured and rotate the range control until the pen position corresponds with the desired line on the paper for this voltage e.g. zero scale deflection.

When the highest voltage to be measured is above 10V i.e. outside the range of the internal reference supplies, set up the scale factor for the lower part of the scale, choosing 10V as 0dB, and the upper part will be automatically calibrated.

Connect the input signal to the red and black input terminals, ensuring that the red terminal is always positive with respect to the black terminal. As the input is floating with respect to earth with a common mode range of $\pm$ 500V, negative signals tied to earth can also be measured providing they are connected in the correct polarity.

Switch to INPUT to plot the log of the input function.

After use switch to either 0dB or INT. REF. and disconnect the input signal line from the input terminals before switching off the recorder.

4. PRINCIPLES OF OPERATION

4.1 Outline of Operation.

The principles of operation of the Logarthmic Amplifier may be explained with the aid of the simplified schematic circuit diagram shown in Fig. 3.

The basic element involved in the generation of the logarithm of the input voltage is the common-base transistor Q1 in the feedback loop of the input operational amplifier. As one of the most predictable non-linear elements commonly available, the bipolar transistor is idealy suited to this purpose, the relationship between its collector current and emitter-base voltage being precisely logarithmic over several decades of current. In the configuration shown the collector current of Q1 is directly proportional to the voltage applied to the input resistor of the virtual earth amplifier. Due to negative feedback the voltage appearing between the emitter and base will automatically reach the value necessary to maintain this current and in doing so provide a level which is proportional to the logarithm of the collector current and, therefore, of the voltage at the input terminals.

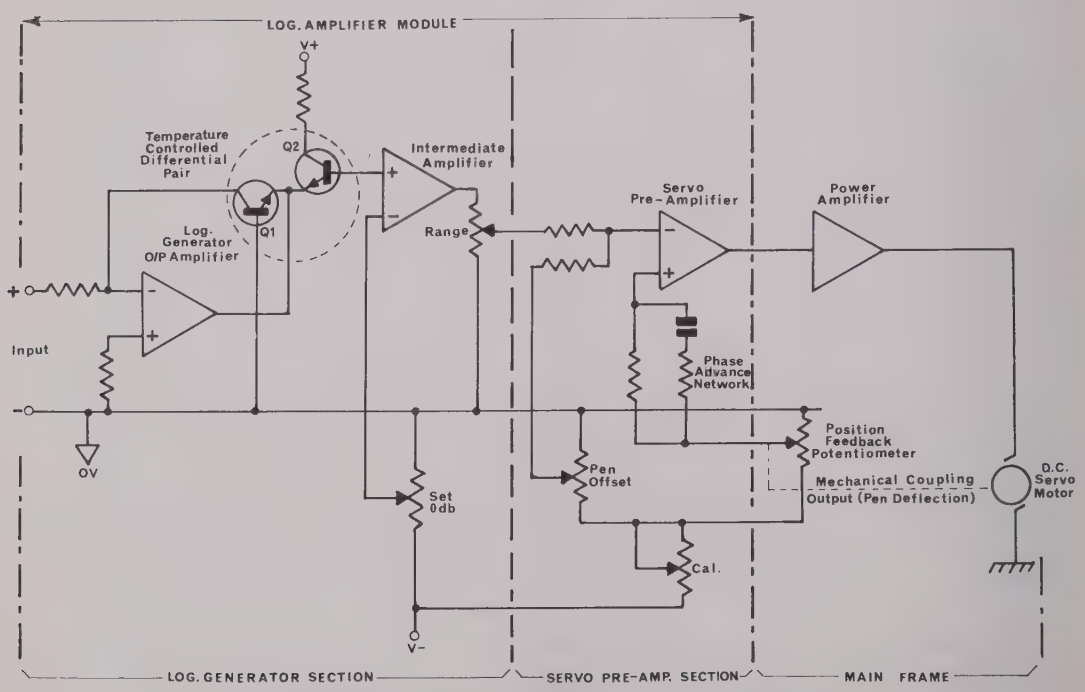


Fig.3 Simplified Schematic Circuit Diagram

By itself as a logarithmic generator the transistor is dependent on the ambient temperature and so to compensate for this a temperature controlled differential transistor pair was utilised in the design. This consists of two matched npn transistors, Q1 and Q2, complete with their own temperature control circuit mounted on a single integrated circuit chip. The temperature of the chip is stabilised at about 70°C to within ± 1°C.

The output from the log generator passes to an intermediate amplifier A104 and then to the servo pre-amplifier A105 which controls the position of the recorder pen by comparing the logarithm signal with the voltage on the wiper of the position feedback potentiometer on the main frame. The error signal thereby obtained is then supplied to the power amplifier which drives the servo motor until the condition is arrived at where the deflection of the pen corresponds with the logarithm of the input signal.

4.2 Circuit Description.

The circuit diagram of the Log. Amplifier is shown in Fig. 7.

The circuit consists of two basic sections the logarithmic generator and the servo pre-amplifier, which are both supplied from a floating power supply.

(a) Log. Generator Section.

Integrated circuits A101 and A102 together form the operational amplifier of the log. generator. A101 is a temperature controlled differential transistor pair which has very low input offset voltage and offset current drifts (typically 0.2uV/°C and 10pA/°C respectively). This is similar to the pair, A103, used as the logarithmic feedback element, except that it is operated at a higher chip temperature (approx. 95°C) to reduce the input bias current.

R111 and R112 are metal film resistors which have close temperature tracking characteristics, their temperature coeficients of resistance being matched to within 10ppm in order to minimise drift.

Negative feedback operates through the common-base transistor Q1 of the temperature controlled differential pair, A103. The voltage at its emitter is proportional to the logarithm of the input voltage at constant temperature. Q2 and the temperature stabilisation circuit compensates for ambient temperature changes so that the voltage at the base of Q2 which is the output of the log. generator, is proportional to the logarithm of the input over a wide temperature range. This voltage level is about -1V for an input of 100mV and decreases by approximately 70mV per decade for increasing input voltages and vice versa.

The base of Q1 is held at about -1V by R117 and R118 in order to keep Q1 out of saturation at the higher collector currents. Also, feedforward directly from the input via R122, VR104 and R121 ensures that there is no reduction in accuracy at these higher currents due to the bulk emitter resistance of Q1.

D102 is an ultra low leakage diode which protects the input of the operational amplifier against a full reverse input voltage. D101 protects Q1 in such an occurence.

VR102 trims the input offset voltage of A101 and VR103 which is a coarse control in series with VR109. The CAL 0.316mV potentiometer, trims the input bias current.

C102 reduces noise at the lower input levels, but at the same time reduces the maximum slewing speeds at these levels, its effect being inversely proportional to the input. Above an input of 10mV the slewing speed is virtually unaffected, being solely determinely by the maximum speed of each axis of the recorder main frame.

The Internal Reference switch S102 is a decade attenuator supplied via R109 and VR 101 from the + 11.7V reference supply. VR101 allows its maximum output voltage to be adjusted accurately to 10V. The attenuator is designed to provide accurate decade voltages when feeding into the 100k ohm input resistance of the log. generator and at the same time to offer a constant load resistance to the + 11.7V supply. The output from the attenuator is connected to the input of the log. generator when S101 is switched to either INT. REF. or 0dB.

The intermediate amplifier A104 acts both as an amplifier and a level shifter. The SET 0dB potentiometer, VR106, controls its output, allowing this to be set at 0V for any output level from the logarithmic generator section corresponding to any particular input level. 0V is the 0dB reference level of the servo pre-amplifier section of the Log. Amplifier (see section 3.3(7)).

The RANGE control VR108 attenuates the output of the intermediate amplifier by a nominal ratio of 3:1 providing a guaranteed scale expansion factor of 2.5:1.

(b) Servo Pre-Amplifier Section.

A105 is the operational amplifier of the servo pre-amplifier section. When S101, the selector switch (see also section 3.3(2)), is switched to INPUT or INT. REF. the wiper of the RANGE control is connected to its inverting input via R127. As the output of the log. generator section is increasingly negative for increasingly positive input signals, a negative reference voltage is supplied to the position feedback potentiometer of the recorder main frame via the calibration potentiometer, VR105. Thus the recorder pen moves in a positive direction for an increasing positive input.

Negative feedback from the wiper of the position feedback potentiometer passes through the phase advance network comprising R131, R132, C103 and C104 to the non-inverting input of A105.

The PEN OFFSET control, VR107, modifies the input current of the inverting input of A105 thereby controlling the position of the pen.

The error signal from the output of A105 is chopped at about 800 Hz by the bipolar chopper consisting of transistors J103 and J104 feeding the output transformer T102. A similar configuration consisting of J105 and J106 forms the phase conscious demodulator providing the d.c. error signal output with respect to ground necessary for driving the power amplifier on the main frame.

(c) Power Supplies.

The power supplies for the Log Amplifier are $\pm$ 15V stabilised and $\pm$ 11.7V reference zener stabilised. These are derived from the 24V stabilised supply of the recorder main frame by means of the 800 Hz (approx.) oscillator consisting of transformer T101 and transistors J101 and J102, and are by this manner isolated from the main frame 0V (ground).

Tappings on T101 also provide $\pm$ 5V square wave drives to the bases of the chopper and de-modulator transistors.

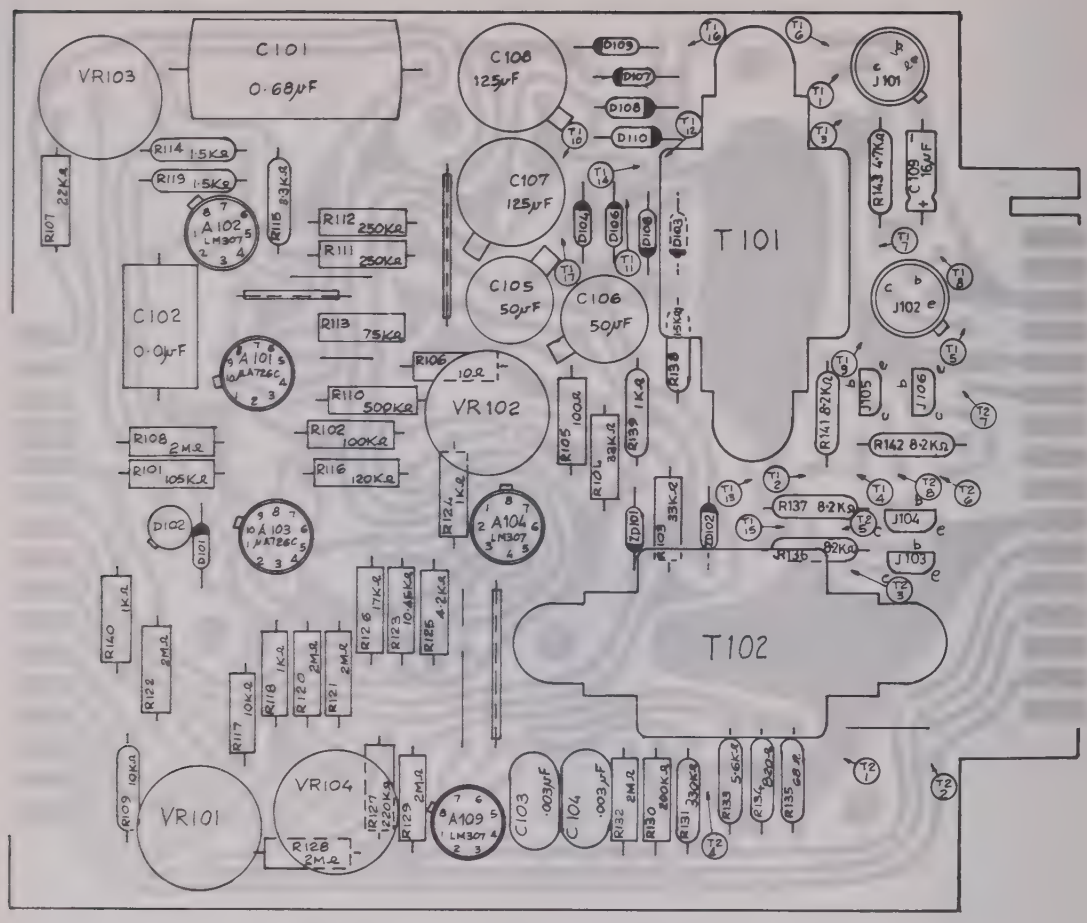
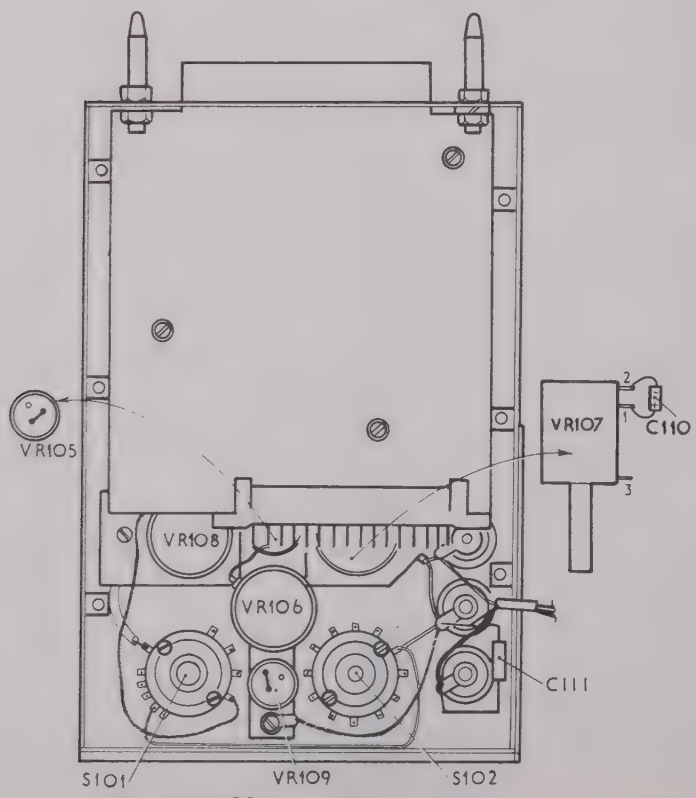


Fig.4 Printed Circuit Board Layout



Fig,5 Module Assembly

5 MAINTENANCE, FAULT FINDING AND SETTING UP PROCEDURE

5.1 Fault Finding.

The following Chart gives symptoms, probable causes and remedies for faults which may be encountered with the Log Amplifier. For faults which are suspected on the recorder main frame or other modules, the user should refer to the main 26000 Operation and Service Manual. If a fault symptom is not listed it is advisable to consult the circuit description and diagram (figure 7) and to perform a logical sequence of voltage and waveform measurements until the faulty component is located. If difficulty is experienced in finding a fault, Bryans Service Department or your nearest Agent will be pleased to advise you, and if necessary supply replacement parts.

A list of components is given at the end of this section in Table 2. The location of the components on the printed circuit board is shown in figure 4 and those on the module in figure 5.

NOTE: If it is found necessary to replace a component it is then usually advisable to perform the setting-up instructions of section 5.2.

TABLE 1

FAULT SYMPTOMS

(a) Faults in Servo Pre-Amplifier Section.

Check with selector switch set to OdB.

Fault Symptom	Probable Cause	Action
Log axis carriage slack in either or both directions OR carriage drives hard in one direction.	(a) Faulty power supplies.	Check with Avo and trace through the $\pm$ 15V & $\pm$ 11.7V supplies derived from oscillator transformer T101. Replace faulty components or rectify fault.

Fault Symptom	Probable Cause	Action
	(b) Fault in A105 or associated circuitry.	Check output of A105 varies ± 14V approx. when carriage is moved from one end of table to other. Also check voltages at pins 5 and 3 of control panel/ printed circuit connector and pin 11 of module/main frame connector. Rectify fault or replace faulty component.
	(c) T102 or chopper and demodulator transistors faulty.	Check waveforms and drives to bases of J103, J104, J105 and J106. Rectify fault or replace faulty component.
PEN OFFSET control non-operative.	VR107 open circuit or broken connection.	Check voltages on terminals of VR107 and also on pin 3 of control panel/printed circuit connector. Rectify fault or replace faulty component.
Log axis oscillates at points.	Position feedback potentiometer dirty.	Clean and lubricate as in main 26000 Operation and Service Manual.

(b) Faults in Log Generator Section.

Check with selector switch set to INT. REF., INPUT or OdB as required.

Fault Symptom	Probable Cause	Action
Log generator completely non-functional - carriage position unaffected by changes in input level or drives hard in either direction.	(a) Fault in power supplies (also may affect servo pre-amplifier section as above).	Check and trace through the ± 15V and ± 11.7V supplies. Rectify fault or replace faulty components.

Fault Symptom	Probable Cause	Action
	(b) Fault in operational amplifiers A101, A102 and associated circuitry or log feedback element A103.	Check voltages. Rectify fault or replace faulty component.
	(c) Disconnection between log generator section and servo pre-amplifier.	Trace through connections to RANGE control VR108, switch S101 and pins 10, 11 and 15 of control panel/printed circuit board connector.
INTERNAL REFERENCE sources non-operative or incorrect at certain levels.	(a) Disconnection or dirty contact in S102.	Check continuity with Avo. Correct disconnection and clean switch contacts.
	(b) No supply to S102.	Check continuity from + 11.7V supply to pin 4 of control panel/ printed circuit board connector and S102. Correct disconnection or replace faulty component.
INTERNAL REFERENCE sources consistantly incorrect throughout complete range.	Setting of VR101 incorrect.	Check first that when checking the accuracy of the INT. REF. that the voltage of the external reference source used is measured directly across the input terminals of the log. amp. If this is done and the accuracy is still out of specification adjust VR101 as in section 5.2.
Non-linearity at high input levels.	Setting of VR104 incorrect.	Re-adjust VR104 as in section 5.2.
Insufficient range of CAL 0.316mV	Setting of VR103 incorrect.	Re-adjust VR103 as in section 5.2.

Fault Symptom	Probable Cause	Action
Input offset current too high or reversed (i.e. a significantly larger or larger reversed input current is required to drive the log. amp. than that dictated by the 100K ohm input impedance).	Setting of VR102 incorrect.	Re-adjust both VR102 and VR101 as in section 5.2.
Noise at low input levels.	(a) Dry joint or bad connection.	Check connections particularly R101 and R102 and correct as necessary.
	(b) A101 noisy or at fault.	Replace A101.
	(c) A103 noisy or at fault.	Replace A103.
	(d) VR102, VR103 or VR104 noisy.	Replace as necessary.
Noise throughout dynamic range.	(a) Excessive hum introduced into Log. Amplifier on signal or due to incorrect earthing.	Check that earth loops between source and recorder do not exist, and that hum on input signal is not excessive. Remove signal leads and switch to 0dB to verify.
	(b) Bad connection on connectors.	Locate and rectify.
	(c) Dry joint or bad connection on printed circuit board or front panel.	Check and correct as necessary.

5.2 Setting-up Procedure.

The following instructions describe how the pre-set potentiometers on the printed circuit board are adjusted for correct operation and optimum performance.

The instructions should be carried out in the order stated, as one adjustment can affect the following adjustments.

For maintenance purposes it may be necessary to adjust only one or two of the potentiometers (as shown in the fault guide chart). In such a case the essential adjustments are as follows:-

(a) When adjusting VR101 all the instructions must be performed.

(b) When adjusting VR104 instructions (5) to (8) inclusive may be omitted.

(c) When adjusting VR102 instructions (5) to (20) inclusive may be omitted.

(d) When adjusting VR103 it is only necessary to complete (1) to (4) inclusive and (21), (22) and (27).

However, if at all in doubt or if a complete check is required, the complete set of instructions should be performed.

Preliminary Instructions.

(1) Plug the module into the X axis of a 26000 A3 recorder.
NOTE: If the recorder in use is an A4 model, the following may still be carried out, but repeated use of the PEN OFFSET control will then be necessary to ensure that the required deflections do not exceed the X axis limits. For example, when adjusting VR101 and VR104, shift the 0dB line to 7.5cm (3 in.) for the 10V and 100V deflections to be included; when adjusting VR102 and and VR103, 0dB may be shifted back to the 20cm (8 in.) deflection line and the associated lower deflections will be as shown in figure 6.

Deflection	0cm 0in	1.25cm 0.5in	2.5cm 1in	5cm 2in	7.5cm 3in	10cm 4in	15cm 6in	20cm 8in	25cm 10in	30cm 12in	35cm 14in
Voltage		0/c			0.316mV	1mV	10mV	100mV	1V	10V	100V
dB		-75	-70	-60	-50	-40	-20	0	20	40	60
Decades	-4	-3.75	-3.5	-3	-2.5	-2	-1	0	1	2	3

FIG. 6 SETTING-UP LEVELS

(2) Switch to 0dB and switch the recorder ON.

(3) Place a sheet of linear metric (or English) graph paper on the recorder and align with the graticule.

(4) ALLOW A 15 MINUTE WARM-UP PERIOD.

INTERNAL REFERENCE Adjustment.

(5) Turn the RANGE control fully CLOCKWISE.

(6) Connect a 10V $\pm$ 0.02V source to the input terminals, ensuring that the positive is connected to the red terminal and the negative to the black terminal. Also ensure that the source voltage is measured with the source connected to the input terminals and that the measuring instrument remains connected.

(7) Switch to INPUT and adjust the SET 0dB potentiometer to bring the pen on to a convenient line on the paper.

(8) Switch the INTERNAL REFERENCE switch to 10V and adjust VR101 (on the P.C.B.) such that there is no more than 0.5mm (0.020 in.) change in deflection when switched from INPUT through to INT. REF.

High Input Linearity Adjustment.

(9) Turn the RANGE control to the CAL position (i.e. fully ANTI-CLOCKWISE) and lock. Then switch to INT. REF. and switch to 100mV.

(10) By means of a screwdriver adjust the SET 0dB potentiometer so that the pen returns to the 20 cm. (8 in.) deflection line. Thus 100mV will be the 0dB level.

(11) Switch to 10V INTERNAL REFERENCE and adjust the CAL potentiometer by means of a screwdriver to give a further deflection of 10 cm. (4 in.) i.e. + 40dB. This will give the required calibrated scale factor of 4dB/cm. (10dB/in.) as in figure 7.

(12) Turn VR102 (on the P.C.B.) about 3/4 clockwise, switch to 1mV, and adjust VR103 (also on the P.C.B.) to give a deflection 10 cm. (4 in.) down on 0dB $\pm$ 5mm. (0.2 in.) i.e. -40dB $\pm$ 2dB or - 2 decades.

(13) Check that the 100mV position has not changed - if it has, shift it back to the 20 cm (8 in.) line and repeat 11, 12 and 13.

(14) Connect a 100V ($\pm$ 1V) source to the input terminals, ensuring that the positive is connected to the red terminal and the negative to the black terminal. Also ensure that the source voltage is measured with the source connected to the input terminals and that the measuring instrument remains connected.

(15) Switch to INPUT and adjust VR104 (on the P.C.B.) to give a pen deflection 15 cm. $\pm$ 0.5 mm. (6 in. $\pm$ 0.02 in.) up on 0dB i.e. + 60dB $\pm$ 0.2 dB, or + 3 decades.

(16) Check 0dB by switching to 100mV on INTERNAL REFERENCE. If a small displacement has occurred, correct this by means of the PEN OFFSET control and repeat 14, 15 and 16.

(17) Repeat 12 and 13 fully.

(18) Repeat 14, 15 and 16.

(19) Repeat 17 and 18 fully until a condition is arrived at where there is the following linearity:-

Voltage	Pen Position	Max Error
100V	35 cm. (14 in.)	$\pm$ 0.5 mm ($\pm$ 0.02 in.) ($\pm$ 0.2dB)
10V	30 cm. (12 in.)	" " "
1V	25 cm. (10 in.)	" " "
100mV	20 cm. (8 in.)	" " "
10mV	15 cm. (6 in.)	" " "
1mV	10 cm. (4 in.)	$\pm$ 5 mm. ($\pm$ 0.2 in.) ($\pm$ 2.0dB)

Input Offset Current and Low Input Linearity Adjustments.

(20) Disconnect the input terminals leaving completely open circuit.

(21) Rotate the CAL 0.316mV potentiometer to $\frac{1}{2}$ range by means of a small screwdriver.

(22) Switch to 0.316mV on INTERNAL REFERENCE and adjust VR103 to give a deflection of 5 in. down on 0dB (i.e. - 50dB or $2\frac{1}{2}$ decades) as near as is possible. Then use the CAL 0.316mV potentiometer for a fine adjustment.

(23) Switch to the open-circuit input. The pen is to move 5.25cm $\pm$ 1.25 cm (2.5 in. $\pm$ 0.5 in.) down on the 0.316mV line (i.e. to the - 75dB line $\pm$ 5dB).

Note the position taken up on open circuit input and switch back to 0.316mV internal reference.

(a) If the pen was positioned to the right of the - 75dB line, turn VR102 slightly clockwise.

(b) If the pen was positioned to the left of the - 75dB line turn VR102 slightly anti-clockwise.

(24) Re-adjust VR103 to return the pen to the 0.316mV line. (i.e. the - 50dB line) as near as is possible. Then use the CAL 0.316mV potentiometer for a fine adjustment.

(25) Repeat 22 and 23 until a deflection of -5.25cm $\pm$ 1.25cm (-2.5in $\pm$ 0.5in.) is obtained when switched from 0.316mV internal reference to open-circuit input.

(26) Repeat 21 and 22.

(27) Finally check the full dynamic range by switching the INTERNAL REFERENCE switch through its complete range of reference levels from 0.316mV to 10V, and the 100V level by means of the 100V external reference source applied to the input terminals. The accuracy of the pen displacements should be within the following limits:-

100V	± 0.5mm (± 0.02")	(± 0.2dB)
10V	" "	"
1V	" "	"
100mV	" "	"
10mV	" "	"
1mV	" "	"
0.316mV	± 1.25mm (± 0.05")	(± 0.5dB)

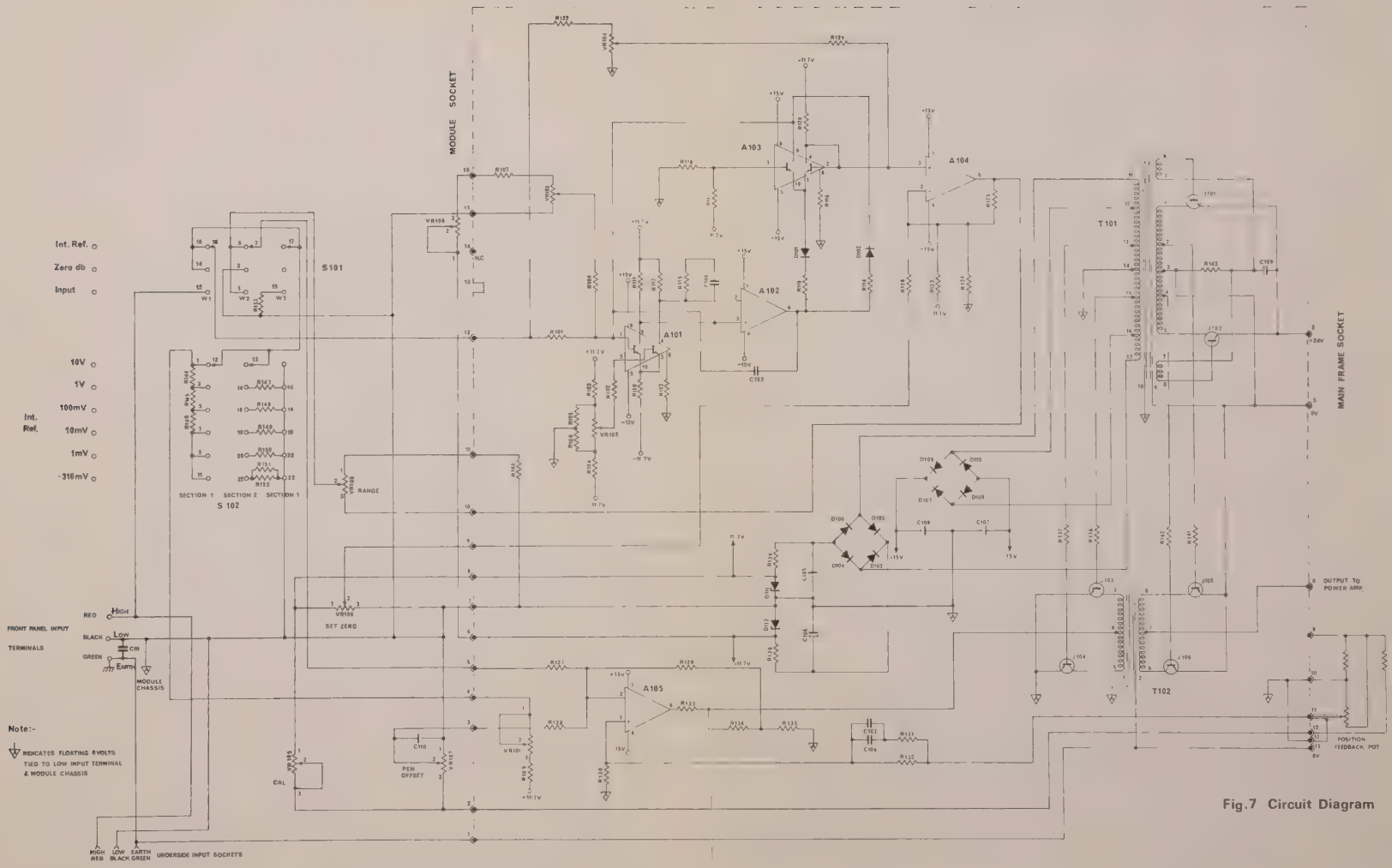


Fig.7 Circuit Diagram

TABLE 2

COMPONENT LIST

PRINTED CIRCUIT BOARD

Resistors

Component Ref.	Value	Type	
R101	105K	Metal Film 0.5% TC 50PPM	¼W
R102	100K	" " " "	⅛W
R103	33K	" " " "	⅛W
R104	33K	" " " "	⅛W
R105	100	" " " "	⅛W
R106	10	" " " "	⅛W
R107	22K	" " " "	⅛W
R108	2M	" " " "	0.1W
R109	10K	Carbon Film 5%	¼W
R110	500K	Metal Film 0.5% TC 50PPM	¼W
R111	250K)	" " " "	⅛W
R112	250K)	TC Matched to 10PPM	
R113	75K	Metal Film 0.5% TC 50PPM	⅛W
R114	1.5K	Carbon Film 5%	¼W
R115	3.3K	" " "	¼W
R116	120K	Metal Film 0.5% TC 50PPM	⅛W
R117	10K	" " " "	⅛W
R118	1K	" " " "	⅛W
R119	1.5K	Carbon Film 5%	¼W
R120	2M	Metal Film 0.5% TC 50PPM	0.1W
R121	2M	" " " "	0.1W
R122	2M	" " " "	0.1W
R123	10.48K	" " " "	⅛W
R124	1K	" " " "	⅛W
R125	4.2K	" " " "	⅛W
R126	17K	" " " "	⅛W
R127	220K	" " " "	⅛W
R128	2M	" " " "	0.1W
R129	2M	" " " "	0.1W
R130	200K	" " " "	⅛W

Component Ref.	Value	Type			
R131	330K	Carbon Film	5%		¼W
R132	2M	Metal Film	0.5% TC 50PPM		0.1W
R133	5.6K	Carbon Film	5%		¼W
R134	820	"	"		¼W
R135	68	"	"		¼W
R136	8.2K	"	"		¼W
R137	8.2K	"	"		¼W
R138	1.5K	"	"		¼W
R139	1K	"	"		¼W
R140	1K	Metal Film	0.5% TC 50PPM		⅛W
R141	8.2K	Carbon Film	5%		¼W
R142	8.2K	"	"		¼W
R143	4.7K	"	"		¼W
VR101	22K	Carbon	Plessey	MPD	
VR102	1K	Wirewound	"	WMP	
VR103	2.2K	Wirewound	"	WMP	
VR104	220K	Carbon	"	MPD	

Capacitors

C101	0.68uF	Polyester	160V	20%
C102	0.01uF	Polystyrene	63V	1%
C103	0.003uF	"	125V	10%
C104	0.003uF	"	"	"
C105	50uF	Electrolytic	25V	
C106	50uF	"	"	
C107	125uF	"	16V	
C108	125uF	"	"	
C109	16uF	"	10V	

Diodes

D101	IS921	Texas Instruments	
D102	BAV48	"	"
D103	IS921	"	"
D104	IS921	"	"
D105	IS921	"	"

Component Ref.	Value	Type
D106	IS921	Texas Instruments
D107	IS921	" "
D108	IS921	" "
D109	IS921	" "
D110	IS921	" "
ZD101	Reference Zener Diode	IN942 International Rectifier
ZD102	Reference Zener Diode	IN942 International Rectifier

Transistors

J101	ACY 17	Mullard
J102	ACY 17	"
J103	ZTX109	Ferranti
J104	ZTX109	"
J105	ZTX109	"
J106	ZTX109	"

Integrated Circuits

A101	uA726C	Fairchild Part No. U5U7726323
A102	LM307H	National Semiconductor
A103	uA726C	Fairchild Part No. U5U7726323
A104	LM307H	National Semiconductor
A105	LM307H	" "
T101	Transformer	Part No. C26236/2
T102	"	" " B26236/3
	Printed Circuit Board Part No. C26236/501	

CONTROL PANEL ASSEMBLY

Resistors

R144	90K	Metal	Film	0.5%	TC 50PPM	$\frac{1}{8}$W
R145	9K	"	"	"	"	$\frac{1}{8}$W
R146	1K	"	"	"	"	$\frac{1}{8}$W

Component Ref.	Value	Type
R147	11.1K	Metal Film 0.5% TC 50PPM ⅛W
R148	1.01K	" " " " ⅛W
R149	100	" " " " ⅛W
R150	10	" " " " ⅛W
R151	6.3	" " " " ⅛W
R152	6.3	" " " " ⅛W
R153	100K	" " " " ⅛W
VR105	2.5K	Reliance Type CW05
VR106	10K	Bourns Type 3507 (ten turn)
VR107	10K	Bourns Type 3507 (ten turn)
VR108	2K	Bourns Type 3507 (ten turn)
VR109	2.5K	Reliance Type CW05

Capacitors

C110	10uF	Electrolytic 16V
C111	0.01uF	Ceramic 500V

MP MASTER
MA23522

PSL/12,73/500